

Deliberate Practice

Variation–Resilient Building Blocks for Ultra–Low–Energy Sub–Threshold Design

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Motivation

- Energy minimization for BSNs
- Operate circuits in sub-threshold
- Tradeoffs
 - Sensitivity to variation
 - Performance



What is Variation?

- Devices performing differently from how they were designed to operate
 - Effects
 - Robustness
 - Performance
 - Causes
 - Process
 - Voltage
 - Temperature

Variation in Sub-Threshold

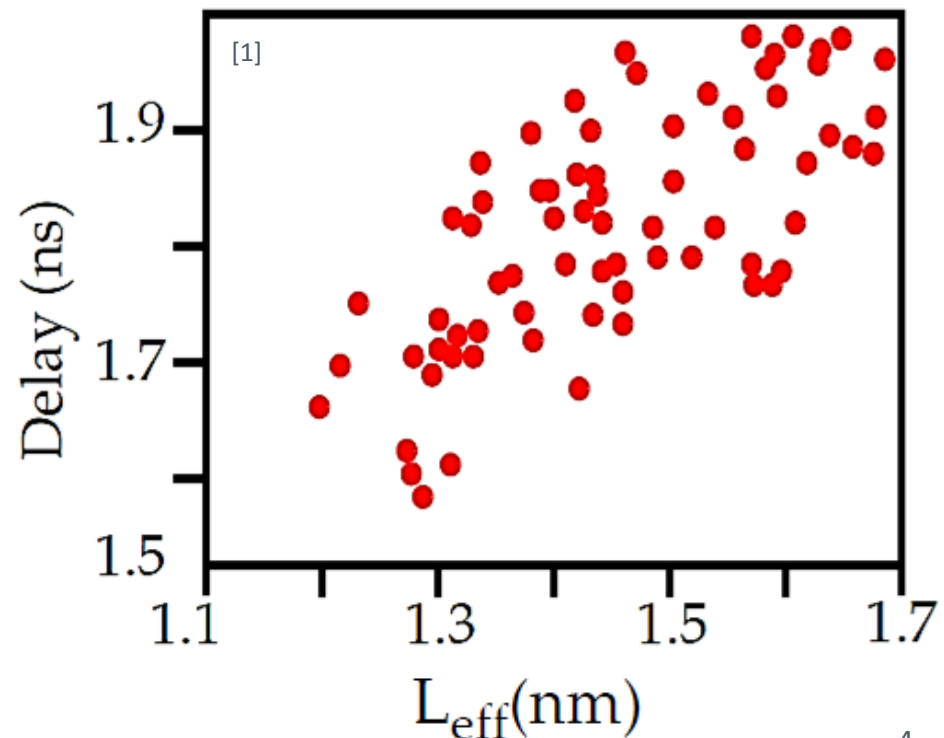
■ Types of Variation

- Random Dopant Fluctuation
- Carrier Mobility
- W/L
 - Lithography
- **Threshold Voltage**
 - Oxide Thickness

■ Analysis Tools

- Monte Carlo
- Corner Analysis

$$I = I_0 e^{\frac{(V_{gs} - V_{th})}{nV_T}}$$





Metrics for Evaluation

1. Energy Consumption

2. Gate Delay

3. Delay Variation $\left(\frac{\sigma}{\mu}\right)$

4. Robustness

1. $\frac{I_{on}}{I_{off}}$

2. Noise Margins (output swing)

5. Area overhead



Attacking the Problem

Block/Logic Level

- ???

Standard Cells

- ???

Device Level

- ???



Research Questions

1. How do you design sub-threshold standard cells capable of MHz operation that are variation-resilient?

Research Questions

1. For an inverter, what design choices can we do to make it variation resilient?

- Area overhead
- Delay Variation $\left(\frac{\sigma}{\mu}\right)$
- Robustness
 - $\frac{I_{on}}{I_{off}}$
 - Noise Margins (output swing)



Research Questions

1. After considering the inverter, what other techniques can we apply to other standard cells?
 1. Combinational
 2. Sequential

References

1. Process Variations, University of Maryland, Advanced VLSI Design:http://www.csee.umbc.edu/~cpatel2/links/640/lectures/lect10_process_var.pdf
2. Reynders, N.; Dehaene, W., "**Variation-Resilient Building Blocks for Ultra-Low-Energy Sub-Threshold Design,**" Circuits and Systems II: Express Briefs, IEEE Transactions on , vol.59, no.12, pp.898,902, Dec. 2012.